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(56) Documents Cited
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GB 1124375 A **GB 0824749 A** **GB 0427351 A**
EP 0012252 A1 **US 4289611 A**

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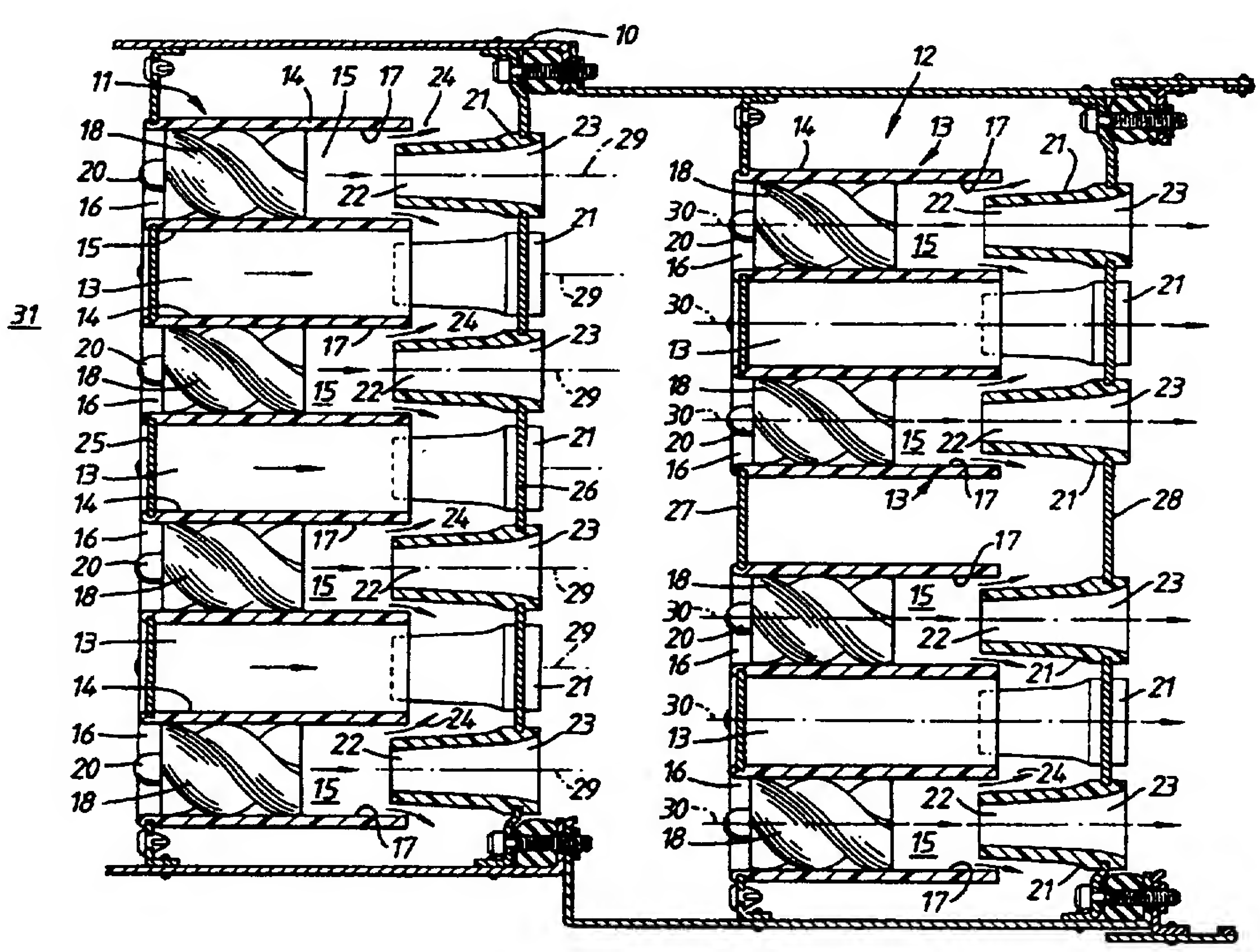
(54) Abstract Title
Separator assemblies

(57) An inertial separator assembly has two stages 11,12. Each stage has an array of centrifugal vortex separator devices 13 defining respective axial paths through the devices for debris-laden air. The axial paths 29 of the first stage are offset from the axial paths 30 of the second stage. This reduces the possibility of residual debris exiting the first stage and entering directly into the second stage since such debris must travel in a lateral path before entering the second stage. The assembly may be used in the air intake of engines to prevent dust, grit, sand, stones etc from entering the engine.



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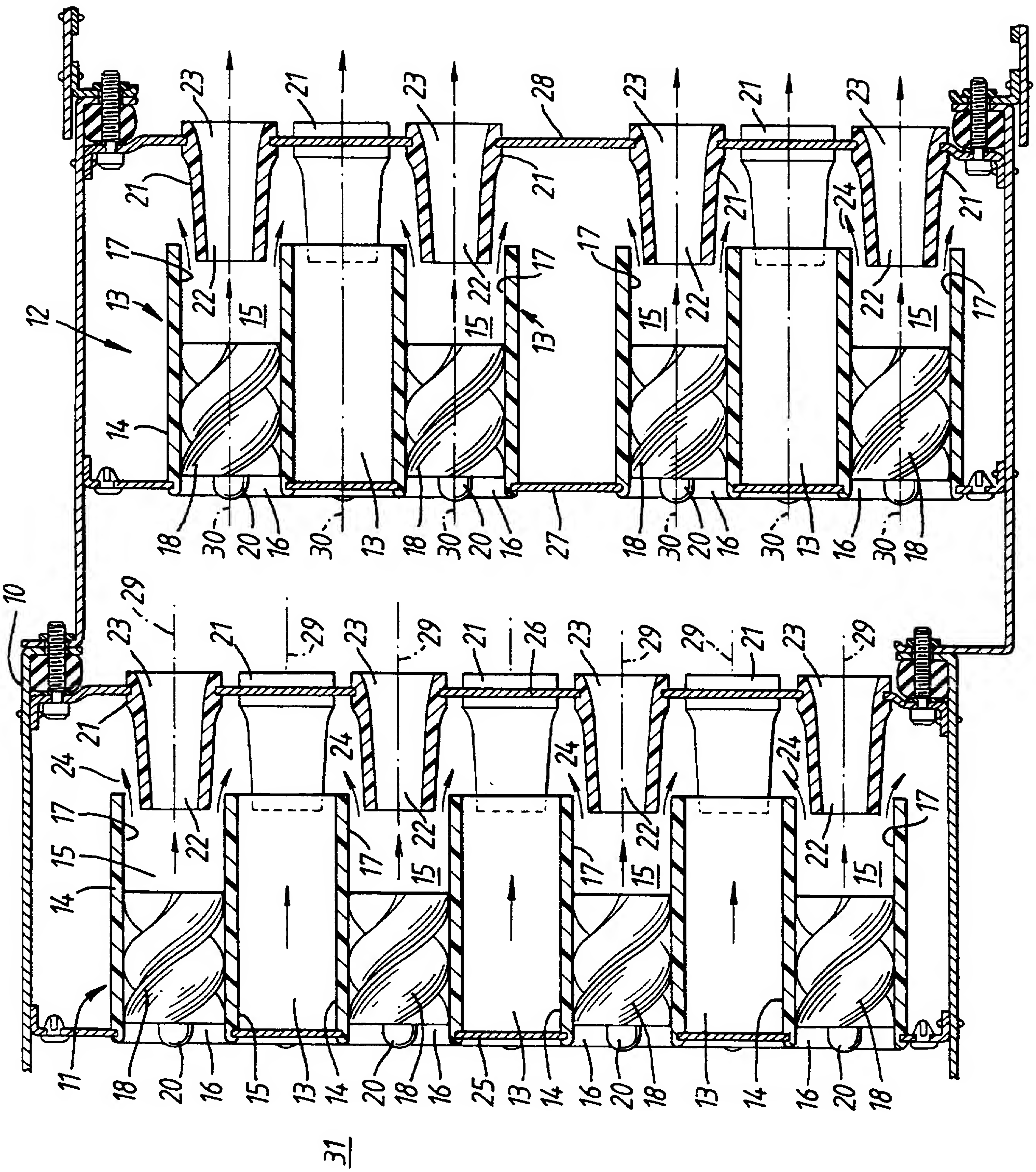
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.



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SEPARATOR ASSEMBLIES

The invention relates to separator assemblies and, in particular, to inertial separator assemblies.

An inertial separator assembly removes particles from fluid flowing through the assembly. Such assemblies may be used in the air intake of engines of all kinds, for example engines for military or off-highway engines. The engines may be petrol or diesel and may be turbo charged. In this case the fluid is air and the particles are dust and other debris such as grit, sand and stones. The assembly includes a number of centrifugal separator devices. Each device imparts a rotational component to the fluid passing through a central passage of the device and this tends to cause the particles to migrate to the periphery of the flow from which the particles are extracted. An example of such a device is shown in GB-A-1207028 where the device is a vortex separator. Similar devices are shown in GB-A-1278488 and GB-A-1236941.

The devices in such an assembly can be arranged in a number of ways. One form of assembly has first and second stages spaced in the direction of flow of the fluid. Each stage has a

number of devices arranged side-by-side with their inlets and outlets in register and the passages parallel to one another. The two stages are identical, so that each device in one stage has a corresponding device in the other stage. The effect of this is that the passage of a device in the first stage is co-axial with the axis of the passage of the corresponding device in the second stage.

As a result of this, any particles that exit from a device in the first stage are directed at a corresponding device in the second stage. This is particularly true of larger particles which can be accelerated as they pass through a device of the first stage and this can cause such particles to pass through the corresponding device of the second stage without being extracted. This is plainly undesirable.

According to a first aspect of the invention, there is provided a separator assembly comprising a first stage including at least one centrifugal separator device through which a fluid flows along a first axial path and a second stage downstream of said first stage and including at least one centrifugal separator device through which said fluid flows along a second axial path, the or all the first axial

path or paths being laterally offset from the or all the second axial path or paths.

According to a second aspect of the invention, there is provided a separator assembly comprising first and second stages, each stage including at least one centrifugal separator device so that fluid flows through said devices in respective axial paths, the fluid flowing in a path between said stages that includes a non-axially directed component.

The following is a more detailed description of an embodiment of the invention, by way of example, reference being made to the accompanying drawing which is a schematic cross-section of a two-stage centrifugal separator for a turbo-blower of a turbo-charged diesel engine.

Referring to the drawing, the separator assembly comprises a casing 10 containing a first separation stage 11 and a second separation stage 12. Each stage 11,12 is formed from a plurality of separator devices 13. The two stages 11,12 are separated by a chamber.

The devices are of known kind and one such device 13 will now

be described briefly. For fuller details of devices of this general kind, reference should be made, for example, to GB-A-1207028.

Each device comprises a tubular body 14 having a central passage 15, an inlet 16 and an outlet 17. A vortex generator 18 is disposed within the central passage 15. The vortex generator 18 may be made of nylon or polypropylene and moulded or bonded in position in the passage 15. The vortex generator 18 has helical vanes surrounding a cylindrical hub 20. The body 14, vortex generator 18 and hub 20 may be moulded as a single item.

A generally tapered tubular outlet member 21 has an inlet 22 and an outlet 23. The outlet member 21 is co-axial with the passage 15 and has the inlet 22 extending into the outlet end 17 of the passage 15. The outer diameter of the inlet 22 of the outlet member 21 is less than the inner diameter of the passage 15 at the passage outlet 17. Thus there is an annular space 24 formed between the outlet 17 of the passage 15 and the outer surface of the inlet end 22 of the outlet member 21.

The device can be manufactured from nylon or thermoplastic

materials and metal and can be produced by assembling a number of components or by moulding more complex sub-assemblies.

As seen in the drawing, each device 13 is mounted between a pair of plates 25,26,27,28. One plate 25,27 engages around the inlet 16 of each passage 15 and the other plate 26,28 engages around the outlet 23 of the outlet member 21.

In each stage, the devices 13 are arranged in rows with the devices 13 of one row being offset by half a passage diameter relative to the devices 13 of the adjacent rows. This is as seen in the Figure. The axes 29 of the devices in the first stage 11 are all parallel and the axes 30 of the devices 13 in the second stage are also all parallel. However, as seen in the drawing, the axes 29 of the first stage 11 are offset from the axes 30 of the second stage 12 by half the passage diameter. This offset is always present but may be more or less than half the passage diameter to optimize performance with different sizes of particulates.

As a result of this, no separator device 13 in the first stage 11 has its axis 29 co-axial with the axis 30 of a device 13 in the second stage 12. This means that no outlet 23 of an

outlet member 21 is aligned with an inlet 16 of a passage 15 of a device 13 in the second stage 12.

The second stage 12 may be followed by a filter (not shown) and may lead to an engine intake. This may be a petrol or a diesel engine which may include a turbo blower.

In use, air enters the casing 10 at a casing inlet 31. The air may be carrying particles such as dust and other debris including grit, sand and stones. The air enters the inlet 16 of the devices 13 in the first stage 11. A vortex is created in the stream of air passing through each vortex generator 18 and the particles are forced to the periphery of each passage 15 leaving the air at the centre relatively clean. The peripheral portion of the air flow carrying the particles exits through the annular space 24 between the passages 15 and the outlet members 21. The core of clean air exits through the outlet members 21 into the space within the casing 10 between the first stage 11 and the second stage 12. The particles that pass through the annular spaces 24 are collected in the space between the downstream plate 26 of the first stage and the upstream plate 27 of the second stage and are extracted from that space.

Although separator devices 13 of the kind described above can have separation efficiencies in excess of 95%, there may still be particles in the air exiting the first stage devices 13. The rotational component of velocity imparted to the air during passage through the vortex generators 18 and the flow acceleration in the outlet member 21 can also impart considerable energy to particles entrained in the air.

The offsetting of the axis 29 of the first stage devices 13 from the axes 30 of the second stage devices 13 reduces the ballistic velocity of any dust or solid particles which pass through the devices of the first stage 11. Thus air passing through the first stage 11 has to divert before entering the inlet 16 of the devices 13 in the second stage 12.

The second stage separator devices 13 operate to extract particles in the same way as the first stage devices 13 as described above. This allows the second stage to have a much higher separation efficiency than would otherwise be the case. It prevents large particles, such as stones, in particular, from getting significant energy in the first stage 11 and passing, on the influence of that energy, straight through the second stage 12. This increases the efficiency of the second

stage 12 and prevents large particles passing the second stage 12 and damaging downstream equipment.

The distance between the first stage 11 and the second stage 12 may be varied as required in order to maximise the efficiency of the second stage 12 having regard to the likely operating conditions.

It will be appreciated that there are a number of variations that can be made. Although the assembly disclosed above has a number of rows of separator devices 13, there may only be one row. Indeed, there may only be one device 13 in each stage. The rows in each stage are laterally offset to obtain the greatest packing density of devices 13 in each stage 11,12. They need not, however, be so offset.

As mentioned above, the offset between the stages can be varied to optimize the overall particulate separation efficiency with particular particulate sizes. For example, the offset may be between 10% and 90% of the tube diameter.

The effect achieved by the arrangement described above with reference to the drawings could also be achieved by having a

the second stage 12. There could be more devices 13 in the first stage 11 than in the second stage 12 or vice versa. In addition, or alternatively, the devices 13 in the first stage 11 may have a different diameter than the devices in the second stage 12.

The vortex-type separator devices 13 described above with reference to the drawings may be replaced by any suitable centrifugal separator.

Although, as described above, the axes 29,30 of the passages 15 in the two stages 11,12 are offset, this need not be the case. As an alternative, deflector plates may be provided in the space between the first and second stages 11,12 to ensure that air and particles exiting from the devices 13 of the first stage 11 travel in a path that includes a non-axially directed component.

Further, although the first and second stages 11,12 are shown as separate structures separated by an air chamber, this need not be the case. Each device 13 of the first stage 11 may occupy a common tubular body 14 with the deflector 18 of the device 13 of the first stage 11 being offset from the vortex generator 18 of the device of the second stage 12.

CLAIMS

1. A separator assembly comprising a first stage including at least one centrifugal separator device through which a fluid flows along a first axial path and a second stage downstream of the first stage and including at least one centrifugal separator device through which fluid flows along a second axial path, the or all the first axial path or paths being laterally offset from the or all the second axial path or paths.

2. A separator assembly comprising first and second stages, each stage including at least one centrifugal separator device, so that fluid flows through the devices of the first and second stages along respective axial paths, the fluid flowing in a path between said stages that includes a non-axially directed component.

3. An assembly according to claim 1 or claim 2 wherein the first stage and the second stage each include a plurality of said centrifugal separator devices, the axial paths of the first stage being parallel to but offset from the axial paths of the second stage.

4. An assembly according to any one of claims 1 to 3 wherein each separator device includes a passage having a diameter, the axial paths of the first stage being offset from the axial paths of the second stage by between 10% and 90%, preferably 50%, of said diameter.

5. An assembly according to claim 1 or claim 2 wherein the first stage and the second stage each include a plurality of said centrifugal separator devices, the first stage including a different number of devices from the second stage.

6. An assembly according to any one of claims 1 to 5 wherein the first stage is separated from the second stage by a chamber into which fluid from the first stage passes and from which fluid passes to the second stage.

7. An assembly according to claim 3 or claim 5 wherein each separator device includes a passage having a diameter, each passage of each separator device of the first stage being continuous with a passage of a separator of the second stage, the first and second stage passages being offset from one another.

8. A separator assembly substantially as hereinbefore described with reference to the accompanying drawings.

9. An air intake for an engine including a separator assembly according to any one of claims 1 to 8.

10. An engine including an air intake according to claim 9.

The Patent Office

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Claims searched:	1, 3-10	**Date of search:**	14 August 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B2P

Int Cl (Ed.6): B04C 3/04, 5/24, 5/26, 7/00 F02C 7/05, 7/052

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2 055 310A	(ROLLS-ROYCE) See figure	1
X	GB 1 214 872	(DEUTSCHE) See cyclone separators 1,2,3 in Figure 1	1
X	GB 1 132 688	(MIAG) See separators in figure	1
X	GB 1 124 375	(INVENTA AG) See separators in Figure 2	1
X	GB 824 749	(COLUMBIAN CARBON) See separators in Figure 2	1
X	GB 427 351	(BERTRAM NORTON) See separators in Figure 1	1
A	EP 0 012 252A1	(PALL CORPORATION) See Figure 3	
A	US 4 289 611	(BROCKMANN) See figure	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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